New frontiers for light storage in hot vapor

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We study two new schemes for quantum memories in warm alkali vapor. In one scheme [Fig. 1(a)], we map the optical field onto the superposition between electronic orbitals in a ladder level scheme. Our fast ladder memory (FLAME) demonstrates high bandwidth, long lifetime, and low noise, and is thus highly suitable for quantum network synchronization. Potentially, FLAME can be performed in miniature vapor-cell devices including optical confinement. A natural extension of FLAME is its integration with Rydberg-level excitations for quantum nonlinear-optics applications. In the second storage scheme [Fig. 1(b)], we map the optical field onto the ground-state spin orientation, which is insensitive to spin-exchange collisions. Doing so, we demonstrate a record 150-millisecond memory lifetime at room-temperature.

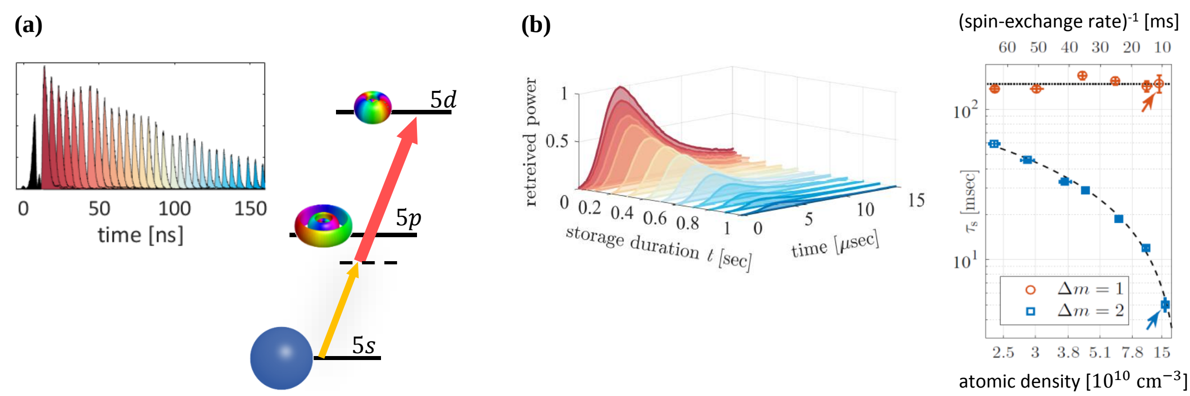

Figure 1. (a) Fast ladder memory (FLAME) comprising purely orbital transitions (here shown for rubidium, with surface colors displaying the phase structure of orbitals 5s, 5p, and 5d). Initially, optical pumping polarizes the nuclear and electronic spins. The storage of the pulsed signal field (yellow) is done by varying the strong control field (red). The graph shows signal traces for different storage times (colors; blackened area marks the leaked portion of the signal). **(b) Storage on spin orientation.** Left: measured retrieved pulses up to 1 second. Right: Storage lifetime as a function of atomic density and spin-exchange rate when storing on the spin-orientation coherence (our scheme $\Delta m = 1$, red), which is unaffected by collisions and thus remains constant (dotted line). The lifetime in a standard scheme ($\Delta m = 2$ coherence, blue) is much smaller and well described by a linear fit (dashed line).

[1] Finkelstein, Poem, Michel, Lahad, and Firstenberg, "Fast, noise-free memory for photon synchronization at room temperature", Science Advance 4, eaap8598 (2018); arXiv:1708.01919.
[2] Katz and Firstenberg, "Light storage for 1 second at room temperature", arXiv:1710.06844.